3-phase motor driver

BA6860FS/BA6862FS

The BA6860FS and BA6862FS are 3-phase, full-wave, pseudo-linear motor drivers suited for driving movie camera capstan motors that can be operated at low voltages. The ICs have a torque ripple cancellation circuit to reduce wow and flutter. The drive mode can be switched to either current or voltage-drive with the mode switching pin. A motor power supply control pin is also built in.

●Applications

Capstan motors of video and movie cameras

●Features

1) 3-phase, full-wave, pseudo-linear drive system.
2) Torque ripple cancellation circuit.
3) Output transistor saturation prevention circuit.
4) Motor power supply control pin.
5) Power saving circuit.
6) Current/voltage drive mode switching pin.
7) Built-in amplifiers.

●Absolute maximum ratings (Ta=25℃)

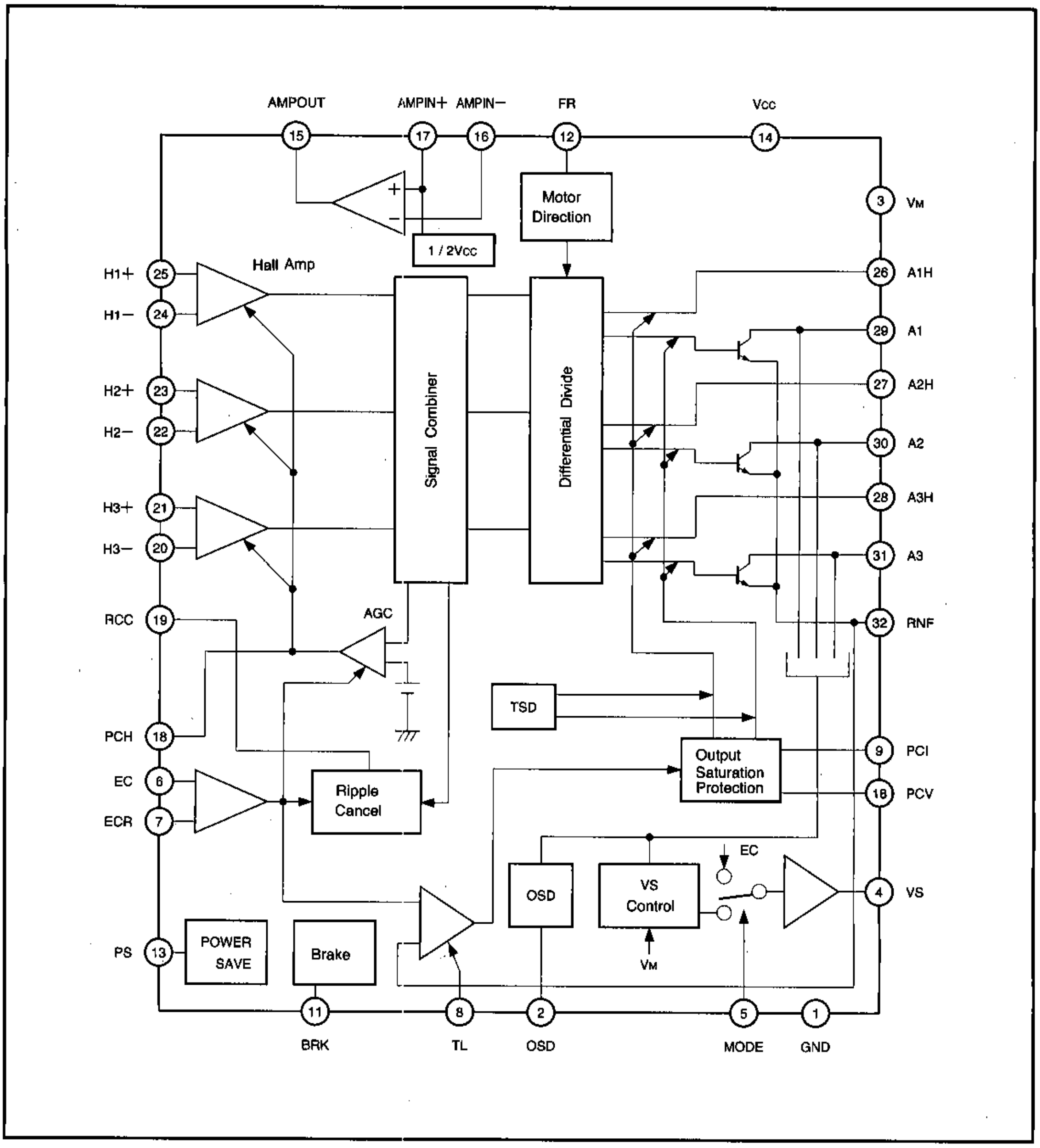
Parameter	Symbol	Limits	Unit
Power supply voltage	V_{CC}	7	V
Power supply voltage	V_M	12	V
Power dissipation	Pd	1000*1	mW
Operating temperature	Topr	−10 ~75	℃
Storage temperature	Tstg	−40 ~150	℃
Allowable output current	$I_{OMax.}$	1*2	A

*1 Mounted on a glass epoxy PCB (70 X 70 X 1.6 mm).
Reduce power by 8 mW for each degree above 25℃.
*2 Should not exceed Pd- or ASO-value.

●Recommended operating conditions (Ta=25℃)

Parameter	Symbol	Range	Unit
Power supply voltage	V_{CC}	3.0 ~ 6.0	V
	V_M	3.0 ~ 10.0	V

● Block diagram

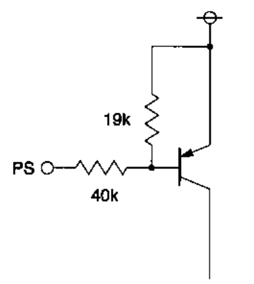


●Pin descriptions

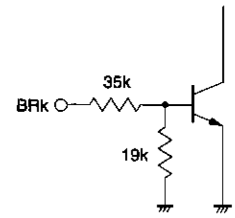
Pin No.	Pin name	Function
1	GND	Signal ground pin
2	OSD	Output short-circuit detection
3	V_M	Motor power supply
4	VS	Motor power supply control
5	MODE	Current/voltage drive mode switching
6	EC	Torque control input
7	ECR	Torque control reference input
8	TL	Torque limit
9	PCI	Phase compensation for the low-side output saturation prevention circuit
10	PCV	Phase compensation for the high-side output saturation prevention circuit
11	BRK	Brake input; brake mode when HIGH, run mode when LOW
12	FR	Motor direction control input
13	PS	Power save input; standby when HIGH, run mode when LOW
14	V_{CC}	Signal power supply
15	AMP OUT	Amplifier output
16	AMP IN−	Amplifier input (-)
17	AMP IN+	Amplifier input (+)
18	PCH	Hall amplifier AGC phase compensation
19	RCC	Resistor connection pin for changing the ripple cancellation ratio
20	H3−	Hall signal input
21	H3+	Hall signal input
22	H2−	Hall signal input
23	H2+	Hall signal input
24	H1−	Hall signal input
25	H1+	Hall signal input
26	A1H	Motor output (pre-drive)
27	A2H	Motor output (pre-drive)
28	A3H	Motor output (pre-drive)
29	A1	Motor output
30	A2	Motor output
31	A3	Motor output
32	RNF	Motor ground pin; connect a current-sensing resistor (0.68 Ω recommended)

●Input/output circuit

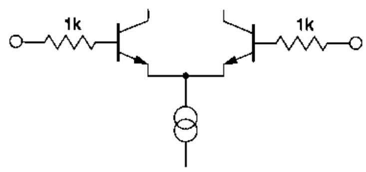
(1) Power save (PS : 13 pin)



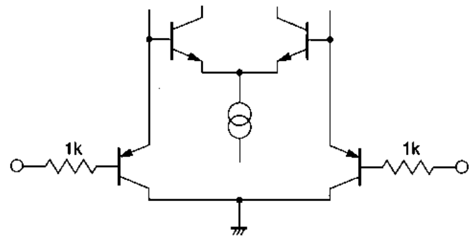
(2) Brake (BRK : 11 pin)



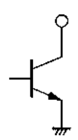
(3) Hall input
(H1+, H1−, H2+, H2− : 25−22 pin)



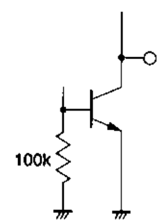
(4) Hall input (H3+, 21 pin ; H3−, 20 pin)



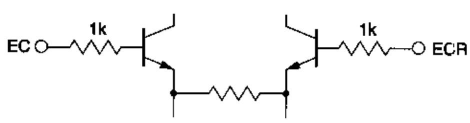
(5) Motor output (A1H, A2H, A3H : 26−28 pin)
Pre-drive



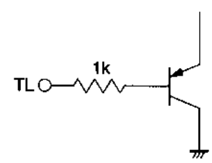
(6) Motor output (A1, A2, A3 : 29−31 pin)



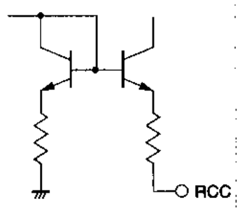
(7) Torque control (EC, 6 pin; ECR, 7 pin)



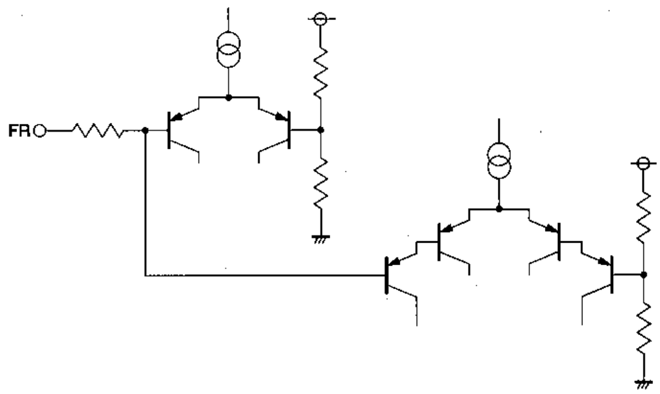
(8) Torque limit (TL : 8 pin)



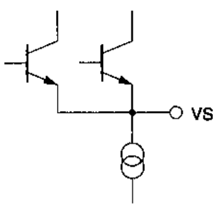
(9) Torque ripple (RCC : 19 pin)



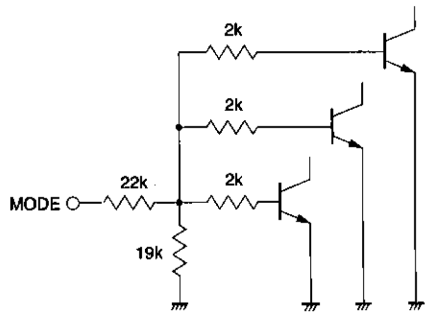
(10) Motor direction (FR : 12 pin)



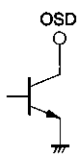
(11) VS (VS : 4 pin)



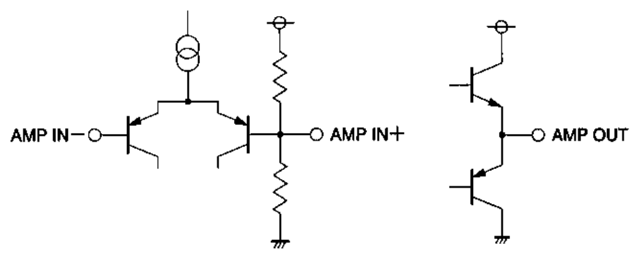
(12) Mode (MODE : 5 pin)



(13) OSD (OSD : 2 pin)



(14) Amplifiers (AMP IN−: 16 pin; AMP IN+: 17 pin; AMP OUT: 15 pin)



* Resistances, in Ω, are typical values. Note that the resistance values can vary ±30%.

Fig.1

● Electrical characteristics (unless otherwise noted, Ta=25°C, V_{CC}=5V, V_M=5V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
〈Total device〉						
Circuit current 1	I_{CC1}	−	0	0.2	mA	Power save ON
Circuit current 2	I_{CC2}	−	7	10	mA	Power save OFF
〈BA6860FS torque control〉						
Torque control I/O gain	G_{io}	0.29	0.39	0.49	A / V	E_{CR}=1.0V, E_C=1.2V, 1.4V
Torque control voltage	E_C	1.0	−	4.5	V	
Torque control voltage offset	E_{COFS}	−100	−	+100	mV	
TL-RNF voltage offset	V_{TLOFS}	20	55	90	mV	V_{TL}=0.2V
Ripple cancellation ratio	V_{RCC}	10	15	20	%	E_C=1.2V, R_{CC}=12kΩ
〈BA6862FS torque control〉						
Torque control I/O gain	G_{io}	0.29	0.39	0.49	A / V	E_{CR}=1.2V, E_C=1.5V, 1.7V
Torque control voltage	E_C	1.2	−	4.5	V	
Torque control voltage offset	E_{COFS}	−150	−	+150	mV	
TL-RNF voltage offset	V_{TLOFS}	20	55	90	mV	V_{TL}=0.2V
Ripple cancellation ratio	V_{RCC}	10	15	20	%	E_C=1.5V, R_{CC}=12kΩ
〈Power save〉						
ON voltage	V_{PSON}	4	−	−	V	
OFF voltage	V_{PSOFF}	−	−	3	V	
〈Hall amplifier〉						
H1 common-mode input voltage	V_{CM1}	1.0	−	4.5	V	FR=GND, V_{CC}
H2 common-mode input voltage	V_{CM2}	1.0	−	4.5	V	FR=GND, V_{CC}
H3 common-mode input voltage	V_{CM3}	0.4	−	3.8	V	FR=GND, V_{CC}
Hall input offset voltage	V_{HOFS}	−15	−	+15	mV	FR=GND, V_{CC}
〈Output〉						
Pre-drive output current	I_{OPRE}	14	23	−	mA	
Low-side saturation voltage	V_{SAT}	−	0.65	1.0	V	I_{OUT}=400mA
〈Motor direction〉						
Forward mode voltage	V_{DF}	−	−	0.8	V	
Stop mode voltage	V_{DS}	1.2	−	2.3	V	
Reverse mode voltage	V_{DR}	2.7	−	−	V	
〈Brake〉						
ON voltage	V_{BRON}	2	−	−	V	
OFF voltage	V_{BROFF}	−	−	1	V	
〈Mode switching〉						
Current-drive ON voltage	V_{IDON}	−	−	1	V	
Voltage-drive ON voltage	V_{VDON}	2	−	−	V	
〈O S D〉						
Output voltage	V_{OSD}	−	0.12	0.18	V	I_{OSD}=3mA

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
〈VS〉						
Voltage gain	G_{VS}	4.5	5.0	5.5	Mult	
HIGH level output voltage 1	V_{OHVS1}	3.50	4.20	—	V	MODE=GND, I_{OVS}=−3mA
LOW level output voltage 1	V_{OLVS1}	—	0.28	0.42	V	MODE=GND, I_{OVS}=50 μA
HIGH level output voltage 2	V_{OHVS2}	3.50	4.20	—	V	MODE=V_{CC}, I_{OVS}=−3mA
LOW level output voltage 2	V_{OLVS2}	—	0.08	0.12	V	MODE=V_{CC}, I_{OVS}=50 μA
〈Operational amplifier〉						
Input offset voltage	V_{IO}	−8	—	8	mV	
DC bias voltage	V_{BIAS}	2.4	2.5	2.6	V	
Voltage gain 1	AV1	65	75	—	dB	f= 500Hz
Voltage gain 2	AV2	30	35	—	dB	f= 50kHz
Common-mode input voltage	V_{ICM}	0.5	—	4.0	V	
High-side output voltage	V_{OH}	3.7	4.1	—	V	I_{OH}=−3mA
Low-side output voltage	V_{OL}	—	0.9	1.3	V	I_{OL}=3mA

* Current flows out from Ics is negative, and current flows into is positive.

●Circuit operation

(1) Hall I/O

The 3-phase Hall signal is amplified in the hall amplifiers and sent to the matrix section, where the signal is further amplified and combined. After the signal is converted to a current in the amplitude control circuit, the current is supplied to the output driver, which then provides a motor drive current. The phases of the Hall input signal, output voltage, and output current are shown in Fig. 2.

The trapezoidal waveform of output current would create intermittence in the magnetic field generated by the 3-phase motor, and would result in an irregular rotation of the motor. To prevent this, the output waveform is obtained by superimposing a triangular wave on the trapezoidal wave. This process is called torque ripple cancellation

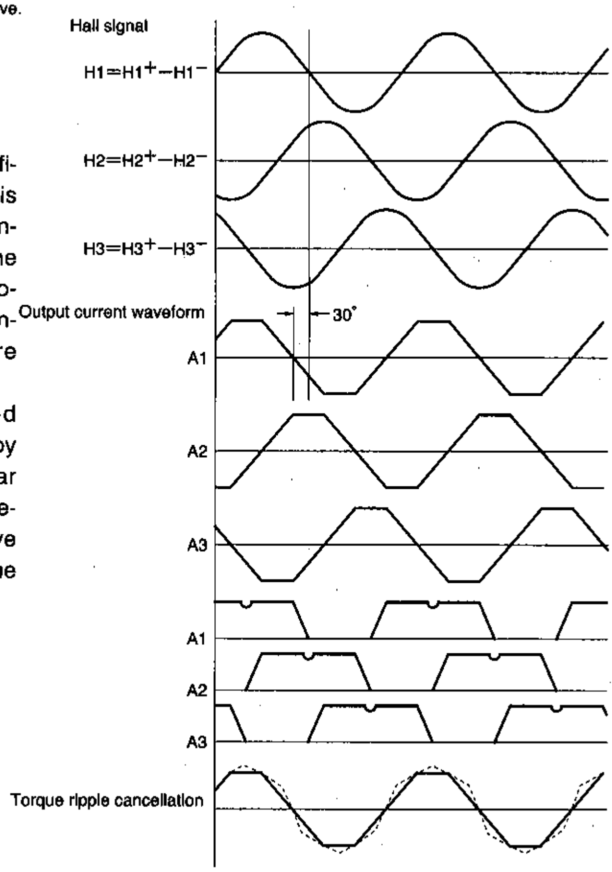


Fig.2 Waveform diagram for the forward mode

●Circuit operation

(2) Torque control pin

The output current can be controlled by adjusting the voltage applied to the torque control pin (EC pin).

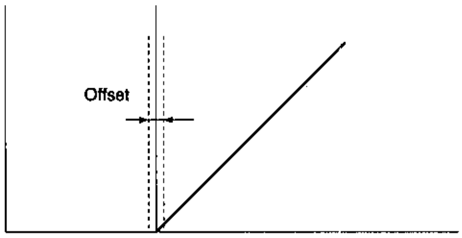


Fig.3

The pins are the inputs to a differential amplifier. A reference voltage of 1.0V (recommended value for BA6860FS) or 1.2V (recommended value for BA6862FS) is applied to pin 7. The offset voltage range is between −100mV and +100mV for the BA6860FS and between −150mV and +150mV for the BA6862FS.

(3) Brake

A brake is applied to the motor when the brake pin (pin 11) is put to HIGH. The brake mode is activated when the brake pin voltage is 2.0V or more and deactivated when the voltage is 1.0V or less.

(4) Output current sensing and torque limitation

The RNF pin (pin 32) is the ground pin for the output stage. To sense the output current, a resistor (0.68Ω recommended) is connected between the RNF pin and the ground. The output current is sensed by applying the voltage developed across this resistor to the TL amplifier input as a feedback.

The output current can be limited by adjusting the voltage applied to pin 8. The current is limited when pin 8 reaches the same potential as pin 32. The output current ($I_{MAX.}$) under this condition is given by :

$$I_{MAX.}=\frac{V_{TL}-(TL-R_{NF}\ \text{offset})}{R_{RNF}}\quad \text{(A)}$$

where R_{RNF} is the value of the resistor connected between the R_{NF} and ground pins and V_{TL} is the voltage applied to the TL pin.

(5) Motor power supply control

Nearly all the power dissipated by the IC is dissipated between the collectors and emitters of the output transistors. More power is consumed as the C-E voltage increases and as the output current increases.

The output transistor C-E voltage is equal to the difference between the supply voltage and the voltage applied to the motor. Because the voltage across the motor decreases with decreasing drive current, the C-E voltage must increase if the supply voltage is fixed.

Therefore, to improve the efficiency of the driver and to prevent the power rating of the IC being exceeded, the supply voltage must be varied in response to changes in the output current. The supply voltage is decreased at low current and increased at high current so that no excessive voltage is applied between the transistor collectors and emitters.

The power supply control circuit (VS ; 4 pin) serves for this purpose. The circuit senses the C-E voltage of the high-side output transistor, and outputs a signal from the VS pin to control the motor power supply.

(6) Motor direction control (FR pin)

The motor mode is :

Forward when the FR-pin voltage is less than 0.8V,
Stop when the voltage is between 1.2~2.3V,
Reverse when the voltage is above 2.7V.

In the stop mode, high- and low-side output transistors are turned off, resulting in a high impedance state.

(7) Output transistor saturation prevention circuit

This circuit monitors the output voltage and maintain the operation of the output transistors below their saturation levels. Operating the transistors in the linear characteristic range provides good control over a wide range of current and good torque characteristics even during overloading.

(8) Ripple cancellation circuit

The cancellation ratio of the torque ripple cancellation circuit (Fig. 2) can be adjusted by an external resistor connected to pin 19. Select a suitable value by taking wow and flutter into consideration.

The ripple cancellation ratio can be obtained in the following manner. With $E_C=1.2V$ for the BA6860FS or $E_C=1.5V$ for the BA6862FS, the R_{NF} value for the Hall input of ($H1^+$, $H2^+$, $H3^+$) = (L, L, H) is denoted as V_1, and the R_{NF} value for the Hall input of ($H1^+$, $H2^+$, $H3^+$) = (L, M, H) is denoted as V_2. The ripple cancellation ratio is then given by :

$$RCC=\frac{V_2-V_1}{(V_1+V_2)/2}\times 100\ (\%)$$

(9) Output short-circuit detection

This circuit detects and alarms when outputs A1, A2, or A3 is short-circuited to the GND or V_M pin. Normally, a pulse with a duty ration of 50% is output from the circuit.

(10) Current/voltage drive mode switching

This circuit turns ON the current-drive mode when the MODE pin is 1.0V or less, and turns ON the voltage-drive mode when the MODE pin is 2.0V or more.

* Note that high- and low-side power transistors are both turned on and a large current flows in the IC when a brake is applied during the voltage-drive mode.

●Application example

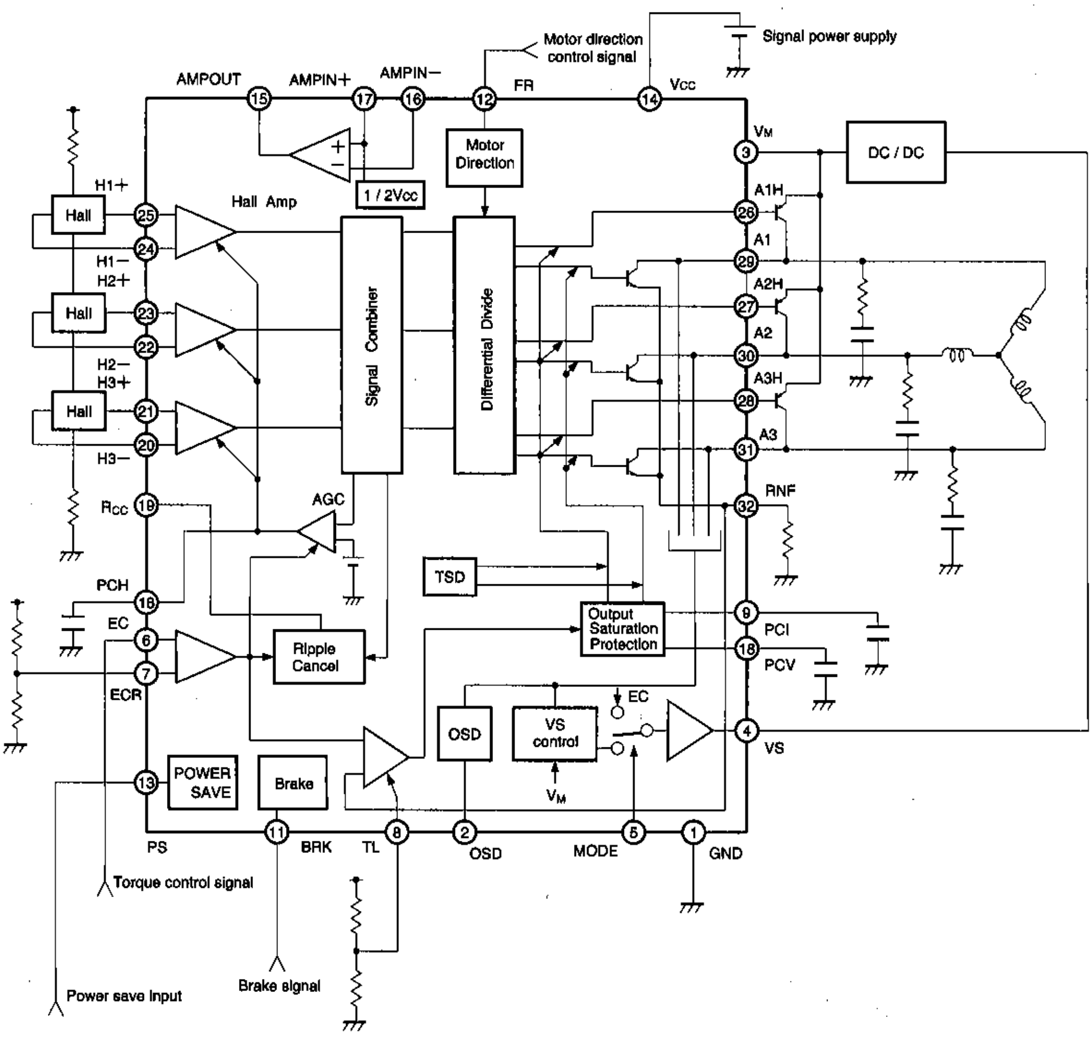


Fig.4

●Operation notes

(1) Thermal shutdown circuit

The BA6860FS and BA6862FS has a built-in thermal shutdown circuit to protect the ICs. The circuit is activated at the temperature of 175℃ (typical) with a hysteresis width of 20℃ (typical).

When the circuit is activated at an elevated chip temperature, the output pins (pins 29, 30, and 31) are set to the open state. The circuit is functional against excessive power dissipation, output short-circuiting, and other irregularities in the output current, but does not work against overheating caused by high internal currents due to externally caused IC damage or pin-to-pin short-circuiting.

(2) Hall input

The Hall input circuits are shown in (3) and (4) of input circuits." Hall devices can be connected in either series or parallel. Make sure that the Hall device input voltage stays within 1.0~4.5V for H1 and H2, and 0.4~3.8V for H3.

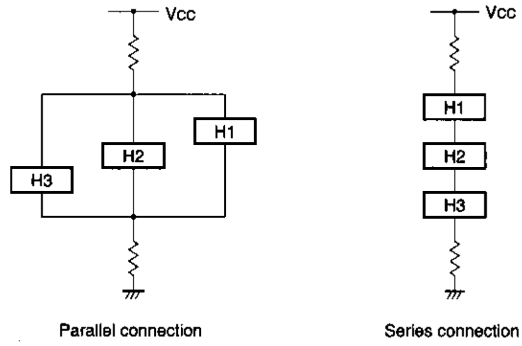


Fig.5

(3) Amplifier

Unpredictable outputs may occur when the amplifier input is outside the recommended range.

●Electrical characteristic curves

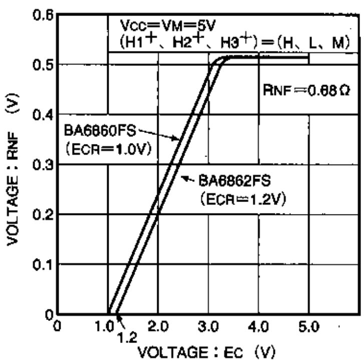


Fig.6 R_{NF} voltage vs. Ec voltage

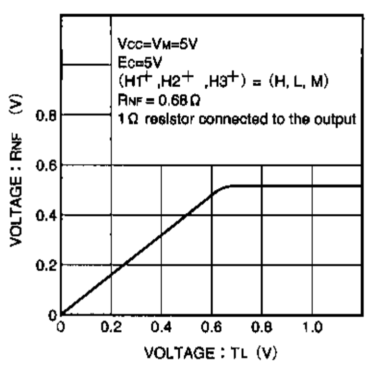


Fig.7 R_{NF} voltage vs. TL voltage

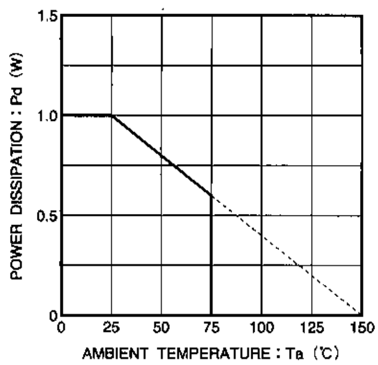


Fig.8 Power dissipation curve

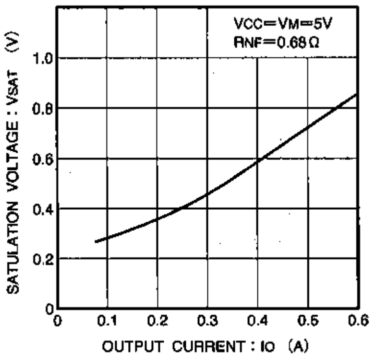


Fig.9 Low-side output saturation voltage vs. output curren

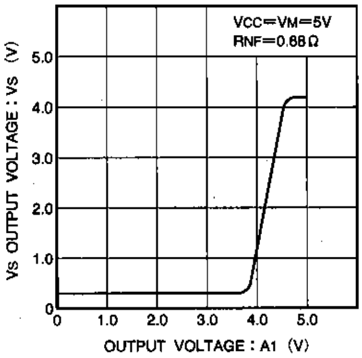
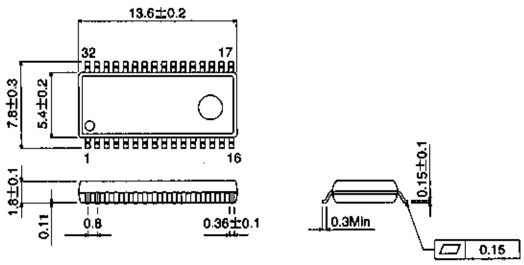


Fig.10 Vs output voltage vs. A1 output voltage

●External dimensions (Units: mm)



SSOP - A32